$Z \rightarrow \mu\mu$ using 2 fb^{-1} data

Muon Momentum Scale Update

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Update of Momentum Scale Study

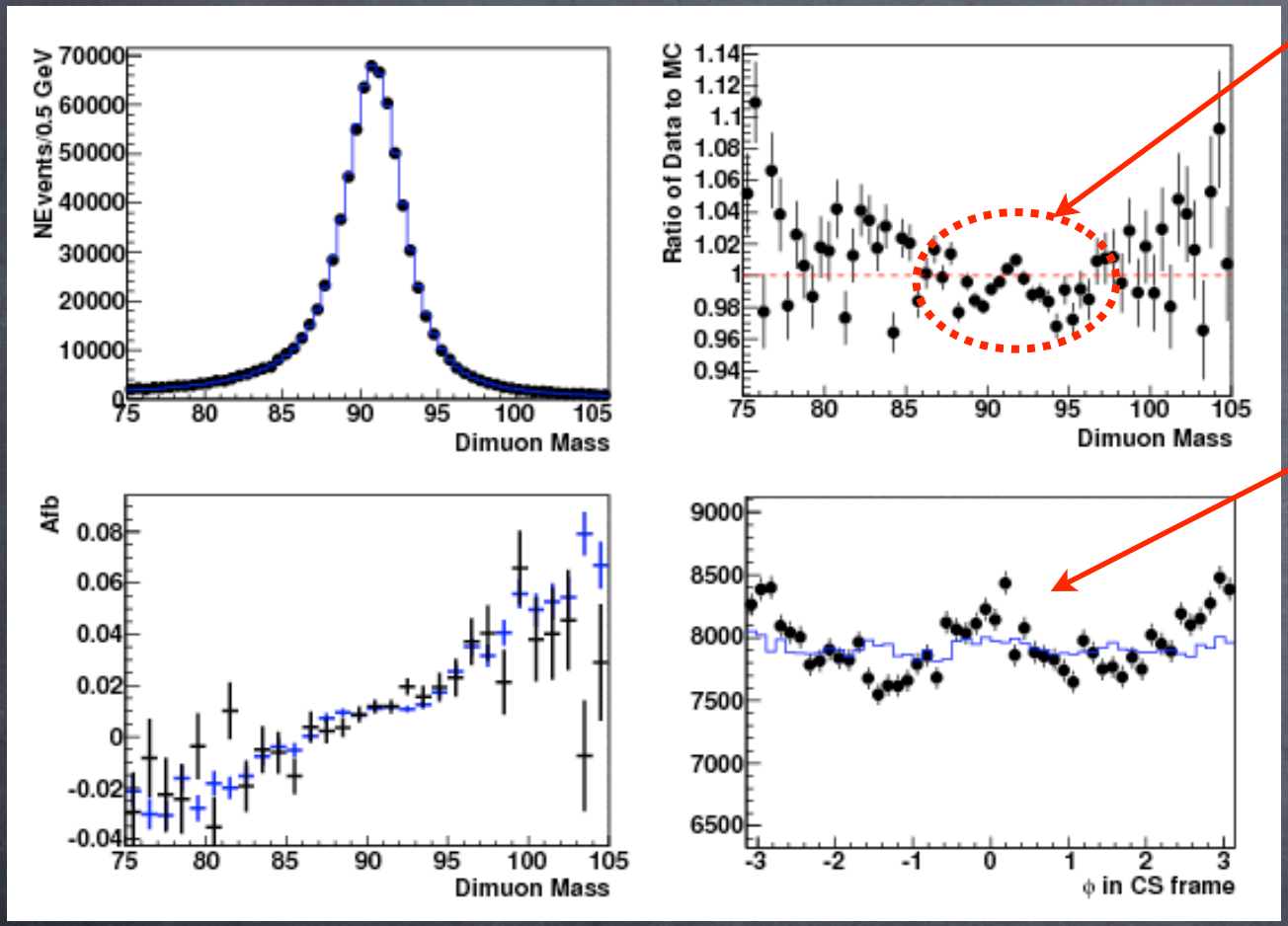
- Momentum scale bias is also important in Z analysis
- Reported the update of muon momentum scale study (2.1 fb^{-1})
  - The correction factor = MuscleFit + Rochester's correction
  - Rochester's correction
    - $\langle 1/p_T \rangle$ correction in 4x4 (η,Φ) : reference point is Gen. level
    - Apply the global factor for resolution and Z mass peak tuning
      - Tuned $p_i = p_i + Tx(Gp_i - p_i)$
        where p_i : 4-mom. of μ, Gp_i : 4-mom. of μ in Gen. level
      - Tuned $p_T = p_T/(1+\Delta x p_T)$: shift $1/p_T$ to match the mass peak
  - Φ_{CS} distribution still shows the discrepancy after all correction
  - Need additional fine tuning to fix Φ_{CS} and Z peak region

Data set and selection

- Data set :
  - 2011A data set : integrated luminosity = 2.1 fb^{-1}
  - Dimuon trigger sample
  - Jason good run required
  - Standard VBTF muon selection required
    - pT>20 GeV/c and |η|<2.1
    - ~0.87 M events selected in 60 < M(μμ) < 120 GeV
- MC set : Summer11 sample (30 M events generated)
  - `DYToMuMu_M-20_CT10_TuneZ2_7TeV-powheg-pythia`
  - Trigger and muon rec. ID efficiency is corrected
    - Efficiencies are estimated using Tag&Probe method

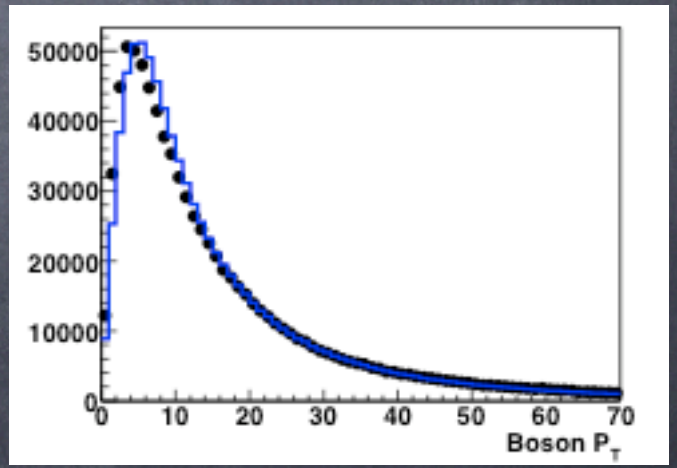
Reference plots after all corrections

- Mass, Afb, ϕ_{CS} after all corrections



Mass shape in peak region is different b/w data and MC
⇒ Hard to match

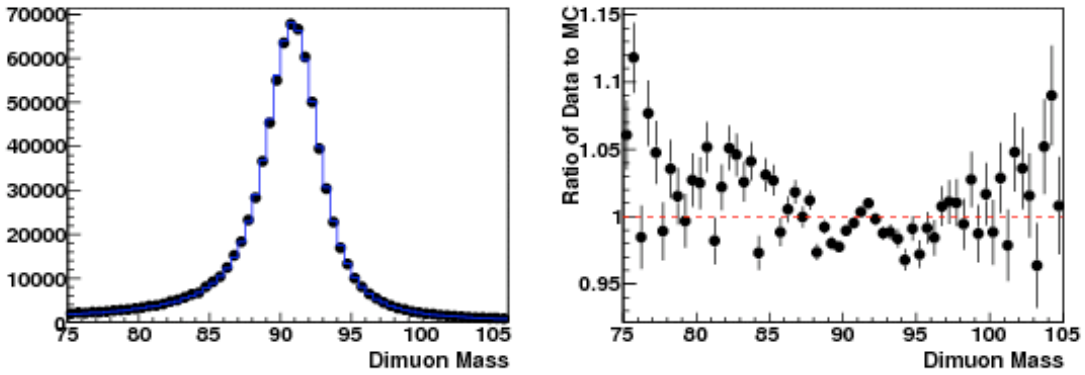
Still MC doesn't agree with the data for ϕ_{CS}
MC is flatter than data
⇒ Working on it

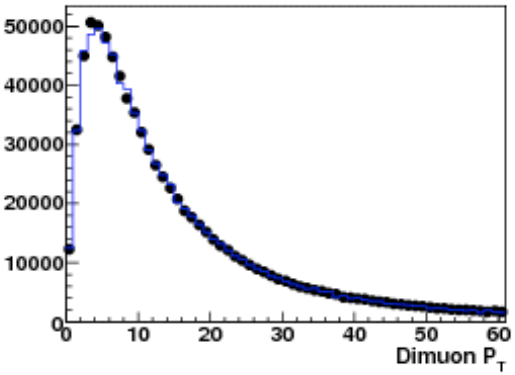


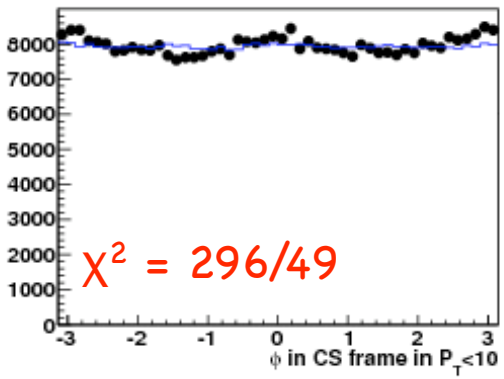
- Possible sources for ϕ_{CS} distribution
  - Z P_T distribution : ϕ_{CS} distribution Z P_T dependence
  - Global factor (T, Δ) has charge dependence

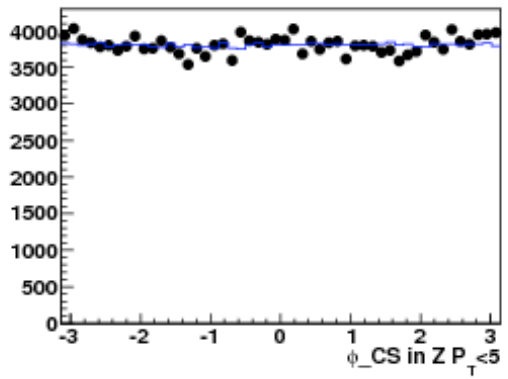
Reference Plot after Z P_T Correction

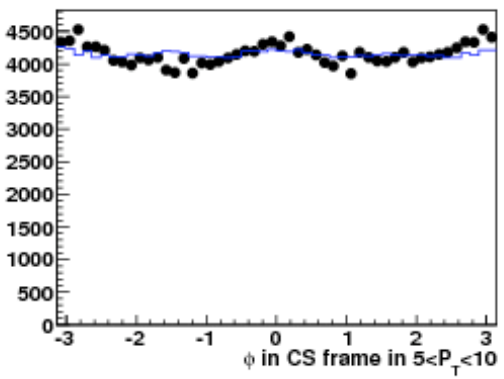
- Z P_T correction is applied and check the reference plots











Z PT correction cannot fix ϕ_{CS} distribution

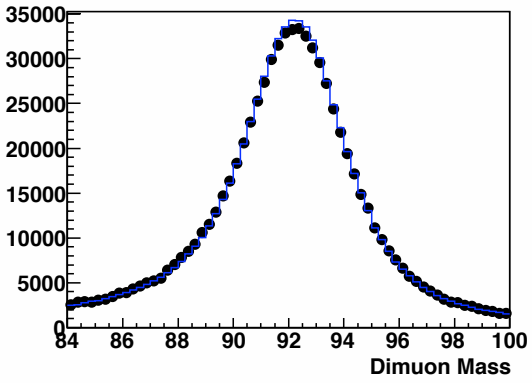
ϕ_{CS} (MC) is flat in ϕ_{CS} < 10

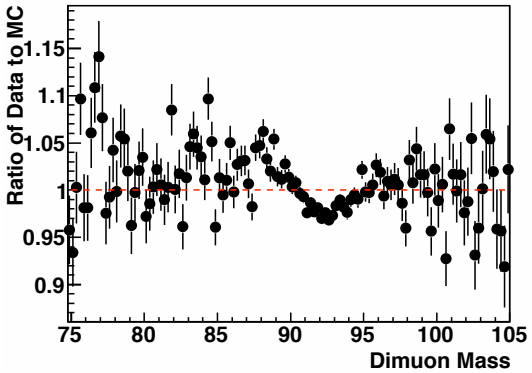
$\Rightarrow$ MuscleFit in MC makes ϕ_{CS} more flatter

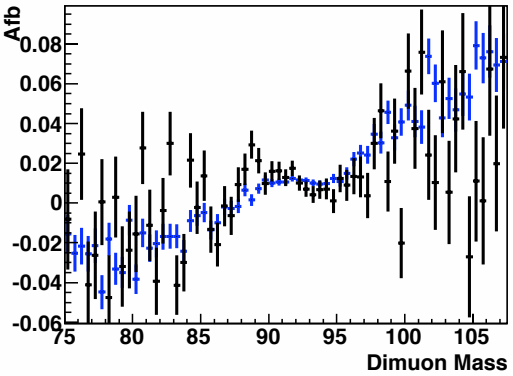
Therefore, decide not to apply MuscleFit

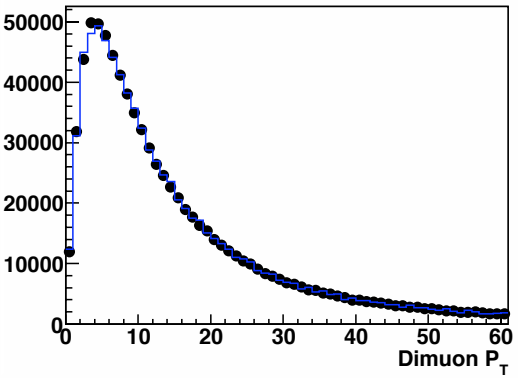
Rochester's Correction + Z P_T Correction

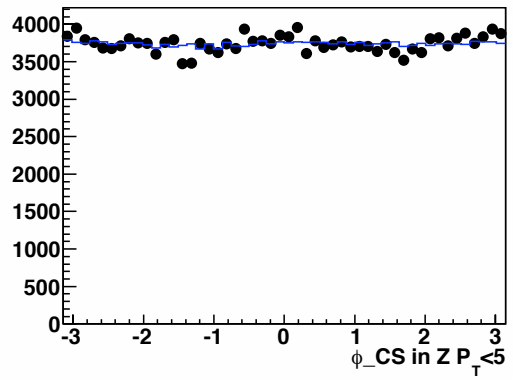
- Rochester's correction + Z P_T correction (no MuscleFit applied)

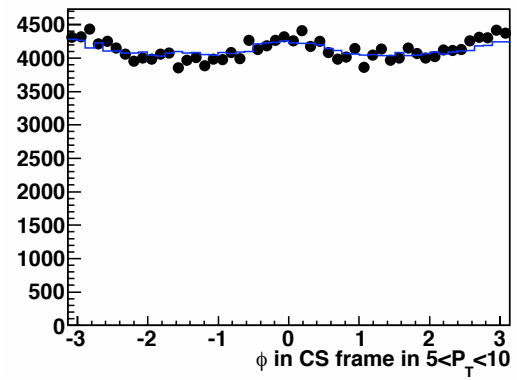












Z peak in MC is slightly higher

ϕ_{CS} (MC) has better matches

$\Rightarrow \chi^2 = 185/49$ in $\phi_{CS} < 10$

Afb is not perfect around Z peak region

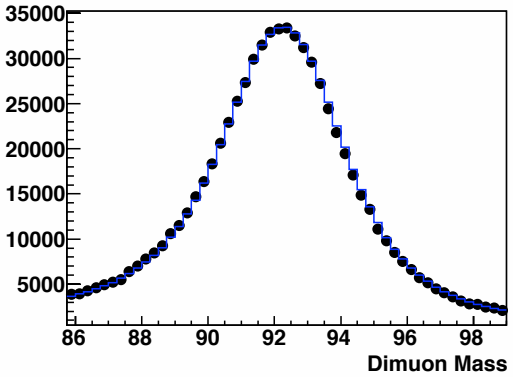
Additional smearing factor for μ^+ and μ^-, respectively

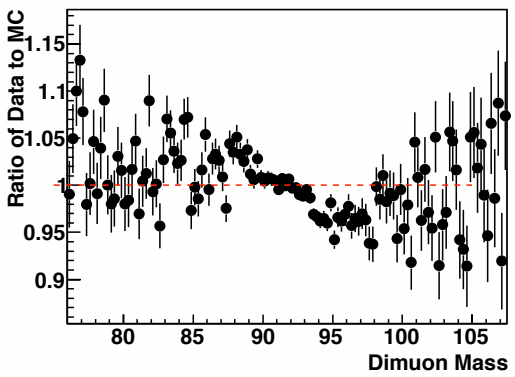
$\Rightarrow$ Smearing factor shows the negative correlation b/w μ^+ and μ^-

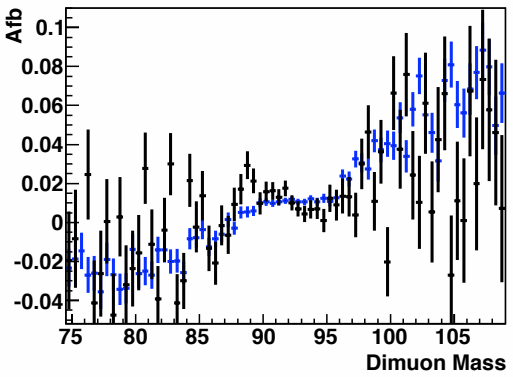
(Reference plots are in next slide)

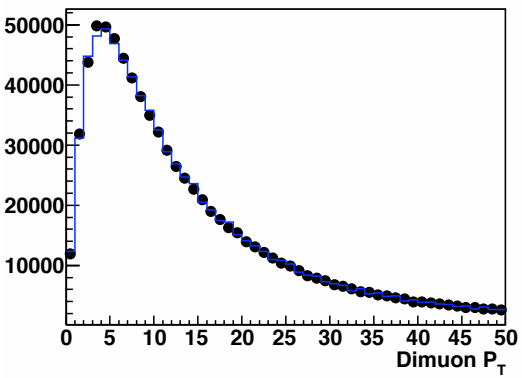
Additional Smearing Factor

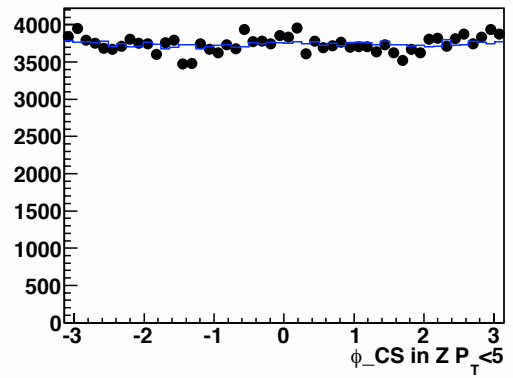
- Additional Smearing Factor : Tuned $p_T = p_T/(1+\Delta^{+/-}xp_TxG(0,1))$

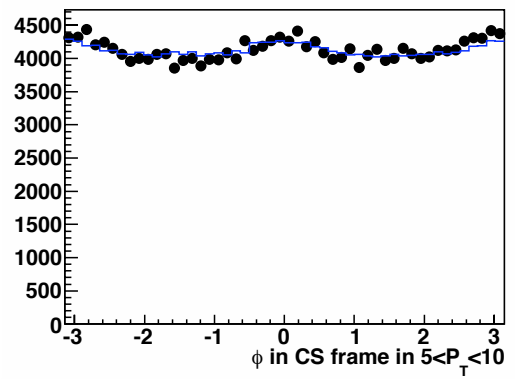












- Δ^+ = 0.000105
- Δ^- = -0.000165
- Z peak in MC is slightly higher
- Afb is still not perfect

$\Rightarrow$ It seems that $\langle 1/p_T \rangle$ correction in 4x4 (η,Φ) matrix is not enough binning

Tested 8x8 binning for η and Φ

$\Rightarrow$ Better match in Afb

Not finalized study yet

Summary

- Muon momentum scale is tested using 2011A data (2.1 fb^{-1})
  - MuscleFit gives bias in MC ϕ_{CS} distribution
  - Z P_T tuning cannot fix ϕ_{CS} distribution
  - Remove MuscleFit and only use Rochester'correction
    - $\langle 1/p_T \rangle$ correction reduces η, ϕ, and charge dependence
    - Global factor is applied into MC for matching mass distribution
    - ϕ_{CS} distribution has better match between data and MC

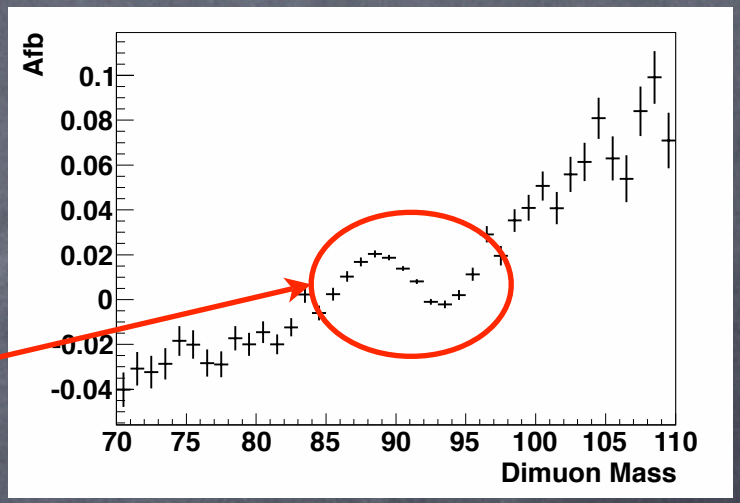
- Z mass distribution and Afb shows slight difference
  - Trying to apply finer binning of $\langle 1/p_T \rangle$ correction
  - Found that the global factor has negative correlation for μ^+/μ^-
  - Will extract the global factor for μ^+/μ^-, respectively

Back-up Slides

Reference plot for study

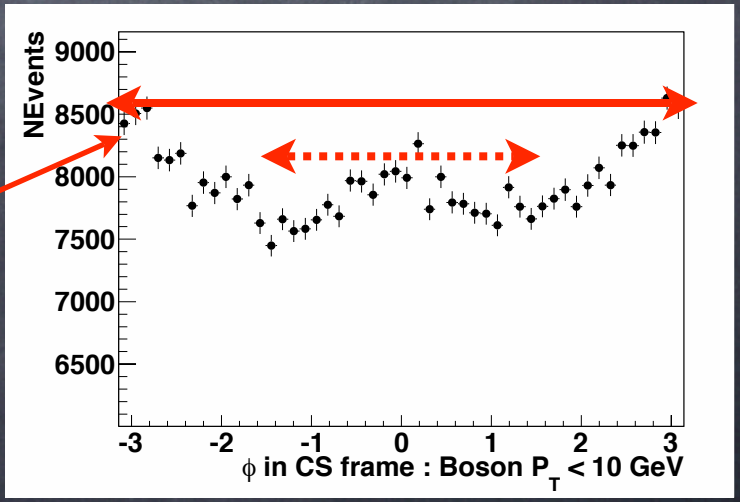
- Three quantities are used as the references of the study
  - Mass distribution :
    - data and MC should agree in mass
    - Apply the correction into MC to match with data
  - Afb :
    - Afb around Z peak region is sensitive to the momentum resolution

Wiggle comes from momentum bias



- ϕ in CS frame for $P_T(\mu\mu) < 10$ GeV
  - CS frame in low P_T region is closed to lab frame

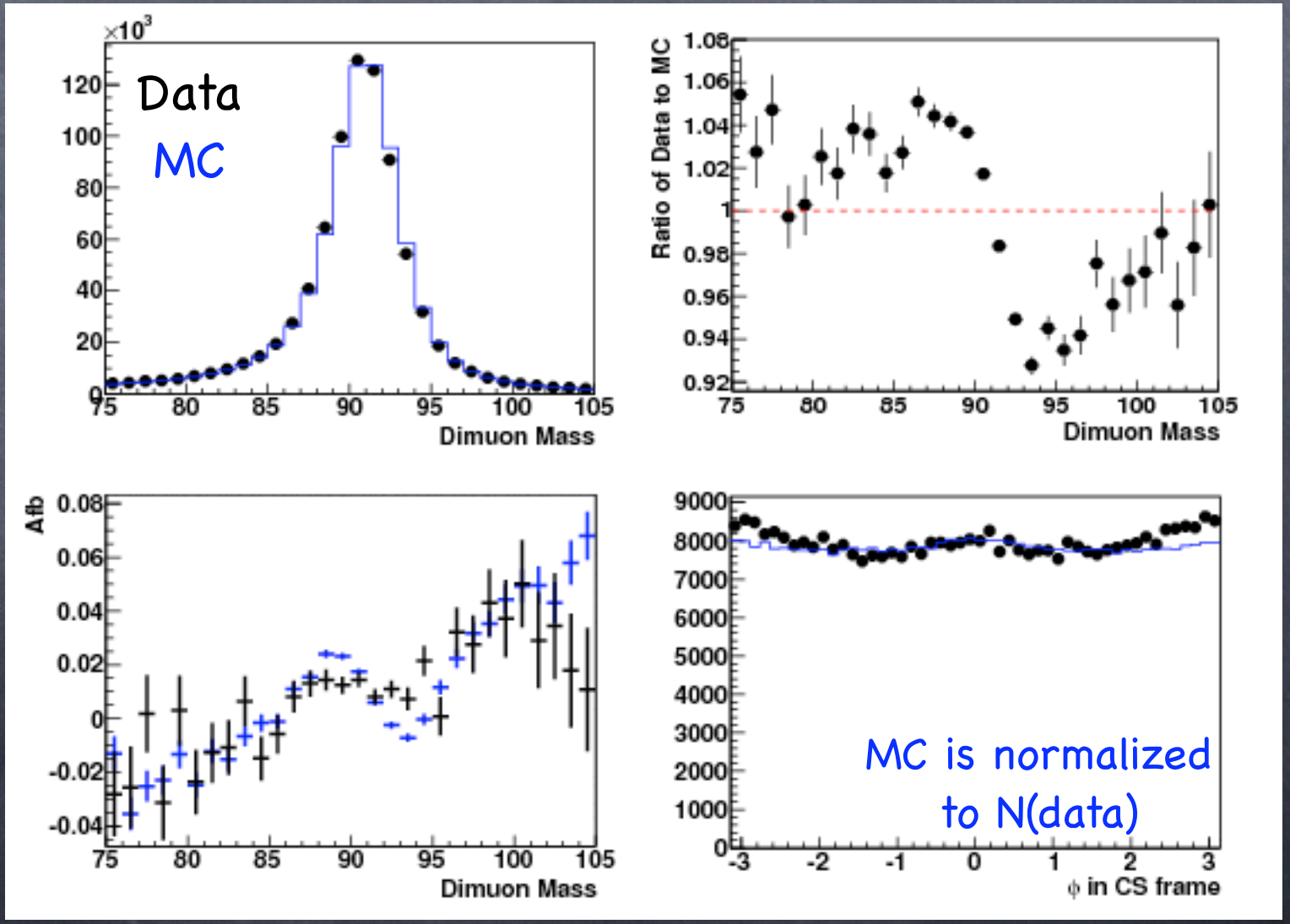
Level of $\phi_{CS} = 0$ should be same to level of $\phi_{CS} = \pm\pi$ (only μ charge flip)



M(μμ), Afb, ϕ_{CS} in data vs. MC

- Reference plots before any momentum correction
  - MC is corrected for efficiencies
  - Background is not subtracted yet → background is very small

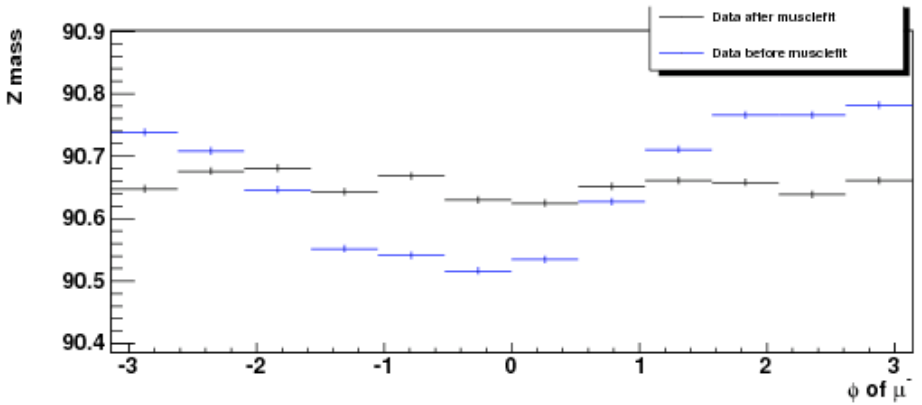
Data and MC has different level of momentum bias

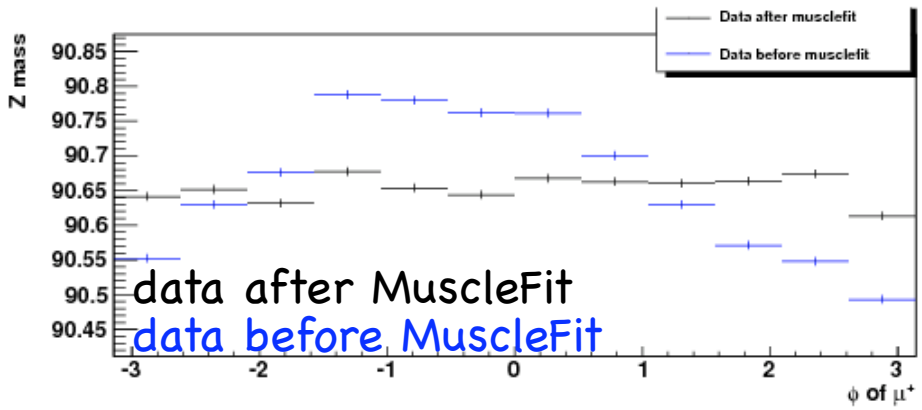


MuscleFit in data

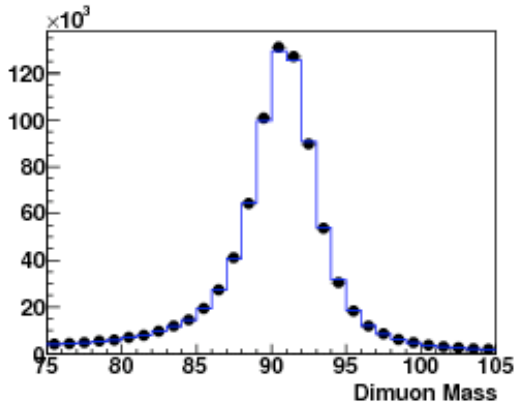
- Mass, Afb, ϕ_{CS} before and after MuscleFit

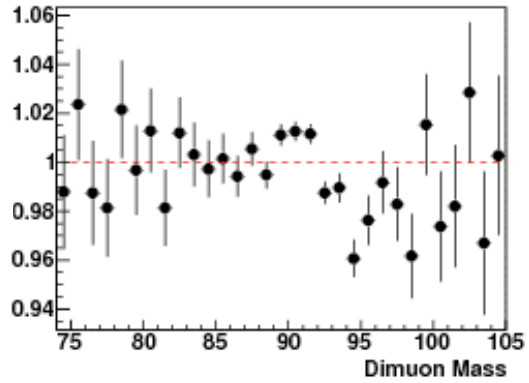
Mass vs. ϕ of μ^-/μ^+

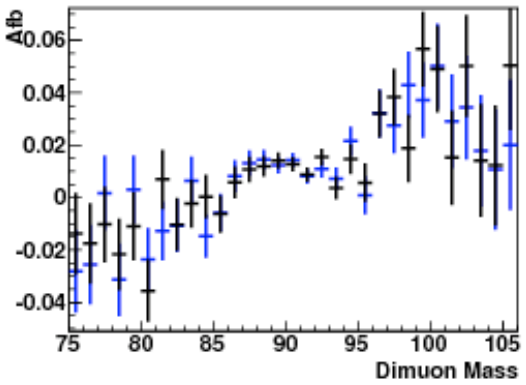


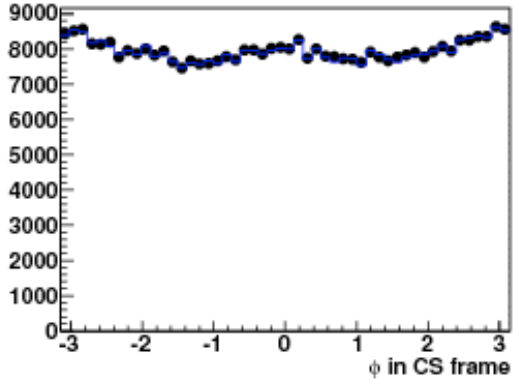


Mass / Afb / ϕ_{CS}







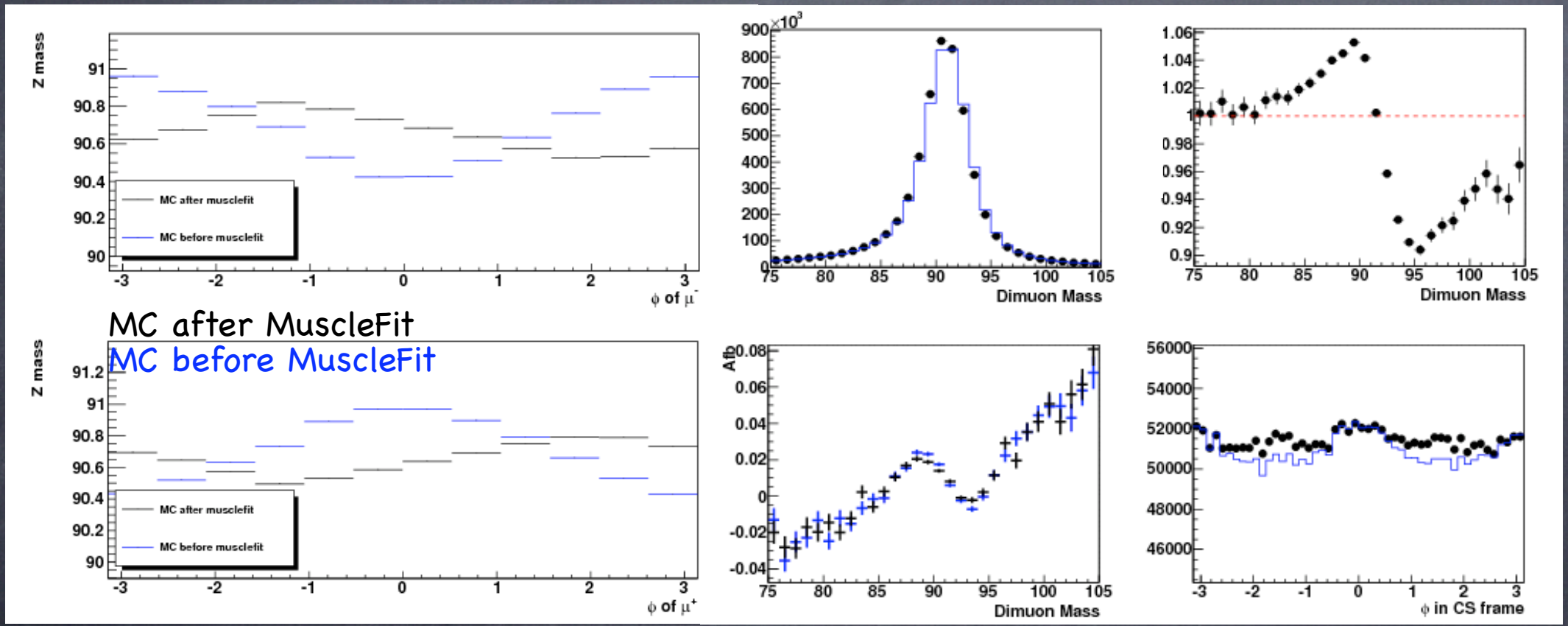


- MuscleFit removed ϕ dependence
- Not much change in Mass, Afb, and ϕ_{CS} distribution

MuscleFit in MC

- Mass, Afb, ϕ_{CS} before(blue) and after(black) MuscleFit

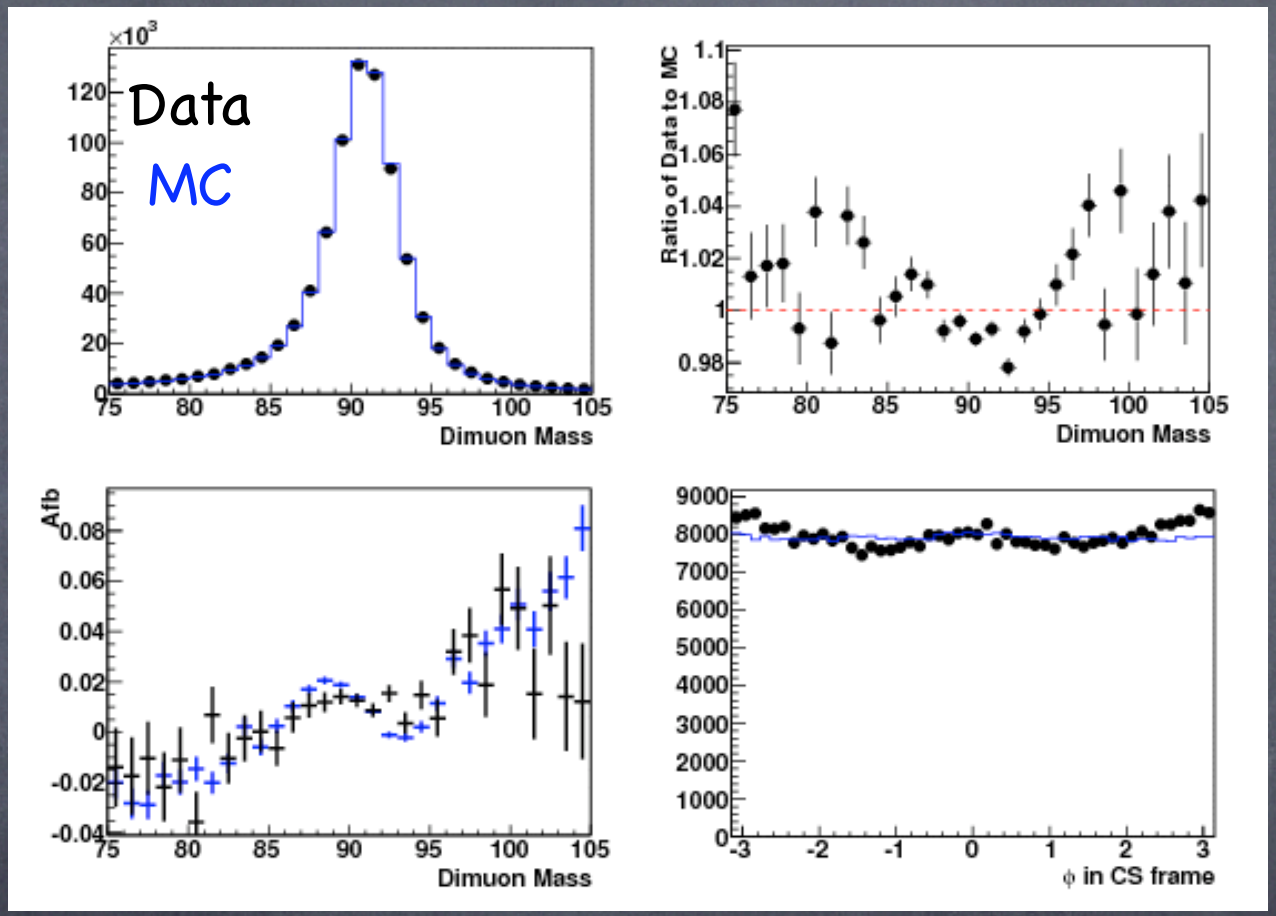
Mass vs. ϕ of μ^-/μ^+ Mass / Afb / ϕ_{CS}



- MuscleFit (2010 version) over-corrects MC for Spring11 MC
- Mass peak shifts by ~0.12% and wiggle of ϕ_{CS} gets flatter
- Not much change in Afb

Data vs. MC after MuscleFit

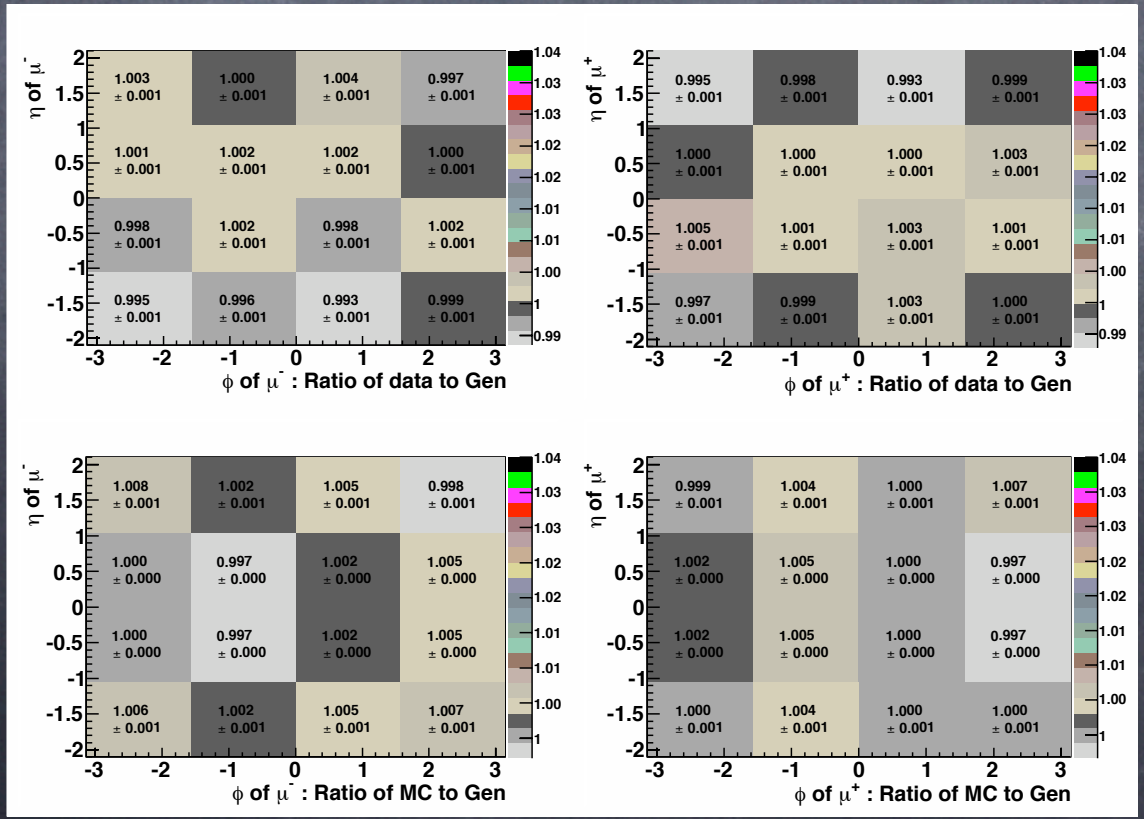
- Mass, Afb, ϕ_{CS} comparison between data and MC after MuscleFit



- Mass has good agreement after MuscleFit
- Afb has still wiggles in data and MC
- ϕ_{CS} distribution shows a discrepancy between data and MC
- ϕ_{CS} in data has different level at $\phi=0$ vs. $\phi=\pm\pi$

Momentum scale using $\langle 1/p_T \rangle$

- Apply additional correction on top of MuscleFit
- (ϕ, η, Q) dependent correction using $\langle 1/p_T \rangle$
  - $\langle 1/p_T \rangle$ of gen. level is used as the reference point
  - Tweak $\langle 1/p_T \rangle$ of data and MC to match $\langle 1/p_T \rangle$ of gen. in MC
  - The correction factor of $\langle 1/p_T \rangle$ is obtained in (ϕ, η, Q)
    - Correction factor = $\langle 1/p_T \rangle$ of data or MC / $\langle 1/p_T \rangle$ of gen.



Global factor for resolution and scale

- Global factor for resolution and momentum scale in MC
  After applying $\langle 1/p_T \rangle$ correction …
  - Need to tweak MC to match to data for Z mass and width
  - Global factor for the resolution and Z mass peak tuning
    - Tuned $p_i = p_i + T \times (Gp_i - p_i)$
      where p_i : 4-mom. of μ, Gp_i : 4-mom. of μ in Gen. level
    - Tuned $p_T = p_T/(1+\Delta \times p_T)$: shift $1/p_T$ to match the mass peak